WETLANDS OF VICTORIA II. WETLANDS AND WATERBIRDS OF SOUTH GIPPSLAND

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Abstract: Wetlands in South Gippsland were located and categorized using water regime and salinity; subcategories were determined using differences in vegetation. Six categories and twelve subcategories were recognized, but 90% of the total wetland area (about 76 000 ha) is intertidal flats. Only 3% of the total area is freshwater wetland and 75% of that is farm dams and water storages. Some 95% of the area of freshwater wetland has been destroyed since settlement.

Counts and observation of waterbirds showed that the most important wetlands in the study area are: (a) deep freshwater marshes on French Island and Phillip Island, where ibis, spoonbill and cormorant breed; (b) the extensive salt pans in the east, which support large numbers of waterfowl and waders; and (c) the intertidal flats, which support most of the Victorian populations of Grey Plover, Mongolian Plover, Eastern Curlew, Whimbrel, Bar-tailed Godwit, Grey-tailed Tattler and Greenshank as well as large numbers of swans and ducks, herons and other wading birds. Examination of records of waterfowl banded in Victoria show that the proportion of bands returned, which have come from the study area, is much higher for Chestnut Teal than for Black Duck or Grey Teal. The salt pan and salt flat subcategories of semipermanent saline wetlands, and deep freshwater marshes in the western part are the only types of wetland adequately reserved in the Wildlife Reserves or National Parks systems.

The swamps at which ibis breed and the roosting and feeding areas of migratory waders must be protected from disturbance and alteration if these components of the waterbird resources of the study area are to be maintained.

INTRODUCTION

Over much of Australia unpredictable rainfall prevents the regular formation of wetlands. Although many species of waterbird, which depend on wetlands for some part of their life cycle, are able to utilize these periodic habitats their survival ultimately depends on the presence of wetlands somewhere within their range at all times, particularly during widespread droughts (e.g. Frith 1967, Cowan 1973). During droughts wetlands are most likely to occur either where rainfall is most certain (i.e. the eastern and northern coastline and the south-west of Australia) or in marine and estuarine habitats. Thus wetlands in such regions are important in providing refuge for birds displaced by drought, as well as supporting locally breeding populations and non-breeding populations of migratory species. Surveys of wetlands in these regions of reliable rainfall have shown (e.g. Riggert 1966, Goodrick 1970, Corrick & Norman 1980) that large areas of wetland have, and could still be, lost because of draining, clearing, cultivation and flood mitigation and irrigation works. As most of Victoria has reliable rainfall the area of each category of wetlands in the state and the extent to which each is used by waterbirds should be documented so that adequate wetlands can be conserved.

STUDY AREA

The study area, approximately 10 000 km², stretches from Merriman Creek in the east to the western edge of the catchment of Western Port and from the southern boundary of the La Trobe River catchment in the north to the coast. Phillip and French Islands in Western Port are also included (Fig. 1).

Human population is greatest in the outer suburban and developing industrial centres along the western boundary (e.g. Hastings — population 2000, Crib Point — 1900 and Ber-

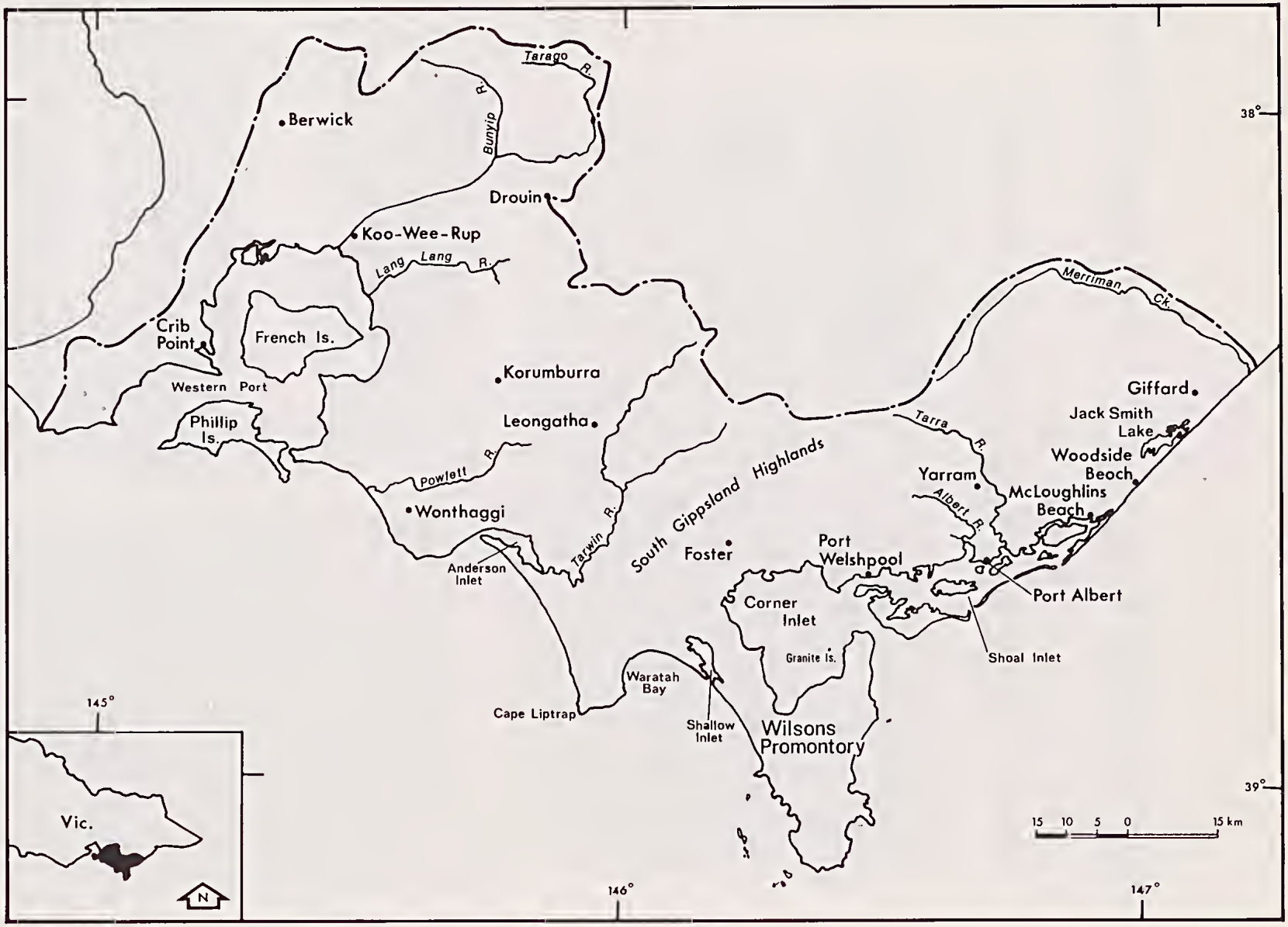

FIG. 1—The study area.

wick — 2000). Across the rest of the area population is based in rural towns (Drouin — 3000, Korumburra — 2900, Leongatha — 3400, Wonthaggi — 4400, and Yarram — 2000; estimated from population in 1971 from Bowden 1977). Many small coastal settlements, particularly on Phillip Island, attract large numbers of holiday makers and day-trippers during summer.

Physiography

The study area has been divided into many physiographic divisions (e.g. Hills 1964, Central Planning Authority 1968); however, in the following discussion divisions of similar topography have been grouped together into two main types: montane and lowland.

The Eastern Highlands and the South Gippsland Ranges, along the northern boundary of the study area, and the ranges of Wilsons Promontory in the south, reach 800 m. Elevation decreases both to the east and to the south where extensions of the ranges reach the coast near Phillip Island and at Cape Liptrap. In all, the ranges occupy some 40% of the study area.

Lowlands are close to sea level and generally have very low relief. South of Powlett River, in the eastern part of the study area and north of Wilsons Promontory, elevation is slightly higher and the relief increased by irregular sand deposits.

Coastal features include the systems of tidal channels, flats and small islands which have been enclosed by sand pits and off-shore sandbars (Jenkin 1968) at Anderson, Shallow and Shoal (i.e. between Port Welshpool and McLoughlin Beach) Inlets and the extensive intertidal flats, fringed in part by mangroves in Western Port and Corner Inlet. Non-tidal low-lying saline areas fed by minor streams have formed behind beach dunes toward the eastern boundary.

Extensive wetlands are restricted, by topography, to intertidal flats and neighbouring salt marshes, to non-tidal areas enclosed by beach sand deposits and to areas of low relief and poor drainage in the lowlands. Smaller wetlands have formed in dune swales where extensive sand deposits occur and in broader sections of river valleys.

Climate

Rainfall is slightly higher in winter and spring than in summer and autumn and increases with altitude. Median (10 and 90 percentiles) rainfall is 1200-1600 mm (800-1200 and 1600-2400 mm) in the South Gippsland Ranges and the north west; 600-800 mm (600-800 and 800-1200 mm) about Western Port; and 400-600 mm (400-600 and 600-800 mm) near Giffard in the east (Bureau of Meteorology 1968).

Droughts of 4 or more months have not been recorded at Warragul, which receives similar rainfall to most of the central part of the study area, but they are more frequent in the west (13% of years) and in the east (18%) (Central Planning Authority 1968).

Temperatures are modified by both altitude and proximity to the coast. In January mean maxima are 24-27°C inland and 21-24°C near the coast, mean minima are 10-13°C throughout. In winter mean maxima are 10-13°C coastal and 7-10°C inland, mean minima are 4-7 and 2-4°C respectively (Department of National Development 1966). Frosts become more frequent with increased altitude and distance from the coast; on the lowlands frosts may occur between mid April and September (Central Planning Authority 1968).

Run-off, after rain, depends on slope, soil and vegetation and evaporation rates. Evaporation rate, which averages 1010 mm p.a. along the coast and 760 mm p.a. in the ranges, is highest during summer (upto 160 mm in January) when it is 3 to 4 times the rainfall (Central Planning Authority 1968). Run-off is thus 25 - 50 mm p.a. near Seaspray, 50 - 120 mm p.a. in the west and 250 - 500 mm p.a. in the ranges (Department of National Development 1966).

Hydrology

Streams in the study area are relatively small; the most important are the Tarwin River (gauged mean annual discharge 284×10^3 ML from a catchment of 1070 km², Bunyip River (153×10^3 ML from 660^3 km²) and Lang Lang River (72×10^3 ML from 300 km²). Flow in all streams is lowest during February and March and peaks during August. Exceptions are Merriman Creek, and Bunyip and Albert Rivers which have highest flows during September, October and June respectively (Bibra & Riggs 1971). These differences reflect local variation in the patterns of rainfall across the study area.

Seventeen urban water trusts and supply authorities operate in the study area; most involve only minor works. The largest storage, Tarago Reservoir, supplies water to the Mornington Peninsula and enables diversion of more than two-thirds of the mean annual flow in the Tarago River (Joseph 1975). Generally diversions for urban water and for irrigation of river flats along other streams only affect flows seriously during summer when flows are lowest.

METHODS

Wetland Distribution

Wetlands were located from aerial photographs (National Mapping, 1:85,000, flown 1967, 1968) from topographic maps and during ground surveys between October 1976 and February 1978. Water source and regime were determined for each wetland and its major plant communities were identified on the aerial photographs. The area of the wetland and vegetation types were calculated from planimeter measurements on the aerial photographs. All wetlands larger than 1.0 ha were included in this survey although some large farm dams constructed since 1968 may have been missed.

Wetland Classification

Distinctive vegetation communities were used to define subcategories within a system of wetland categories based on salinity and water regime. All categories and subcategories, other than intertidal flats, used in this report have been described previously (Corrick & Norman 1980), but all are summarized in Table 1. Intertidal flats are permanent saline wetlands which include both sandy areas usually devoid of vegetation and a variety of muddy substrates with a covering of marine halophytes (*Ruppia maritima, Zostera* sp. etc.) and algae. The flats are delimited by sandy beaches, mangroves and salt marshes and their extent and duration of exposure during each tidal cycle vary considerably with slope, variation in

Table 1
Characteristic water regime and vegetation of the wetland categories and subcategories of the study area.

Category	*Depth (m)*	*Duration of inundation*	*Subcategory*	*Typical vegetation*
Freshwater				
1 Flooded river flats	<2 m	<7 days	none	Determined by agricultural practice
3 Shallow marshes	<0.5 m	<6 months		
			.1 Herb-dominated	Annual moist soil and aquatic species
			.2 Sedge-dominated	*Lepidosperma longitudinale*
4 Deep marshes	<2 m	12 months		
			.1 Shrub-dominated	*Melaleuca ericifolia*
			.2 Reed-dominated	*Phragmites australis* and *Typha* spp.
			.4 Sedge-dominated	*Lepidosperma longitudinale*
			.5 Open water	Submerged aquatic species[1]
5 Permanent open water	>2 m	permanent	none	Submerged aquatic species, emergent species in the littoral zone[2]
Saltwater				
6 Semipermanent	<2 m	<8 months		
			.1 Salt pans	*Lepilaena* spp, *Ruppia maritima*[3]
			.2 Salt meadow	Halophytes with *Ruppia* & *Lepilaena* in shallows.
			.3 Salt flats	Dense ground cover of halophytes
7 Permanent	>0			
			.3 Intertidal flats	*Zostera* sp. various algae, none in places[4]

[1] Moist soil annuals in littoral zone.
[2] The distribution of aquatic species is limited by turbidity and emergent species by grazing and tramping by stock and by shore slope and aspect.
[3] No vegetation when dry.
[4] Excludes mangroves, most sand flats have no vegetation.

TABLE 2
THE NUMBER OF WETLANDS OF EACH CATEGORY AND THE NUMBER OF AREAS OF EACH WETLAND SUBCATEGORY IN EACH WETLAND SIZE RANGE (Category 1 River flats have been omitted).

Category/subcategory	*Number of wetlands in the following size (ha) ranges*					*Total number*	
	1-5	*6-10*	*11-25*	*26-100*	*>100*	*Subcategory*	*Category*
3 Shallow freshwater marsh							
.1 Herb-dominated	1					1	
.2 Sedge-dominated	3					3	
Number of wetlands	4						4
4 Deep freshwater marsh							
.1 Shrub-dominated	1	1	4	2		8	
.2 Reed-dominated	1		3			4	
.3 Sedge-dominated	22	5		4		31	
.5 Open water	41	4	8	3		56	
Number of wetlands	59	8	8	5			80
5 Permanent open freshwater	44	6		2	2		
Number of wetlands	44	6		2	2		54
6 Semipermanent saline							
.1 Salt pan	14	1	6	10	6	37	
.2 Salt meadow	4	8	9	11	8	40	
.3 Salt flat				1	2	3	
Number of wetlands	17	9	11	13	10		60
7 Permanent saline							
.3 Intertidal mudflat					4	4	
Number of wetlands					4		4
Total number of wetlands	124	23	19	20	16		202

tide height and the occurrence and direction of strong winds.

WATERBIRD DISTRIBUTION AND ABUNDANCE

The occurrence and abundance of all species of waterbirds was recorded. Large wetlands were visited several times during the study period. Intertidal areas about Corner and Shoal Inlets were surveyed on successive days (5-10 March and 24-29 November 1977) so that the number of migratory waders could be counted. The survey of Western Port was less thorough as it has been well documented by the Bird Observers Club (BOC) (see Loyn 1978). However, areas not included in the BOC surveys were visited and observations made of the distribution of birds at low tide. Ibis colonies and swamps on French Island were visited between 11 and 17 October 1977.

ANALYSIS OF WATERFOWL BANDING DATA

Waterfowl have been banded in Victoria mostly (81%) at the Division's Serendip Wildlife Research Station near Lara (38°01'S 144°25'E) (McNally & Falconer 1953, Norman 1973). The number of recoveries of banded birds during hunting seasons between 1951 and 1977, is compared with those from elsewhere in Australia and the distribution of recoveries is plotted on a 10 minute grid of the study area.

RESULTS

WETLAND DISTRIBUTION

Within the study area 202 wetlands totalling 75 900 ha were located. Tables 2 and 3 show distribution and area of each category and subcategory amongst various wetland size classes. More than half (124) of the wetlands are small (1-5 ha) amounting to only 0.4% of the total area. Fourteen wetlands are larger than 100 ha amounting to 98% of the total.

Freshwater wetlands form 3% (2270 ha) of the total but 75% of these and all the permanent open freshwater, is man-made dams and reservoirs. Permanent saline wetlands are all greater than 100 ha, and comprise 90% of wetland area. Distribu-

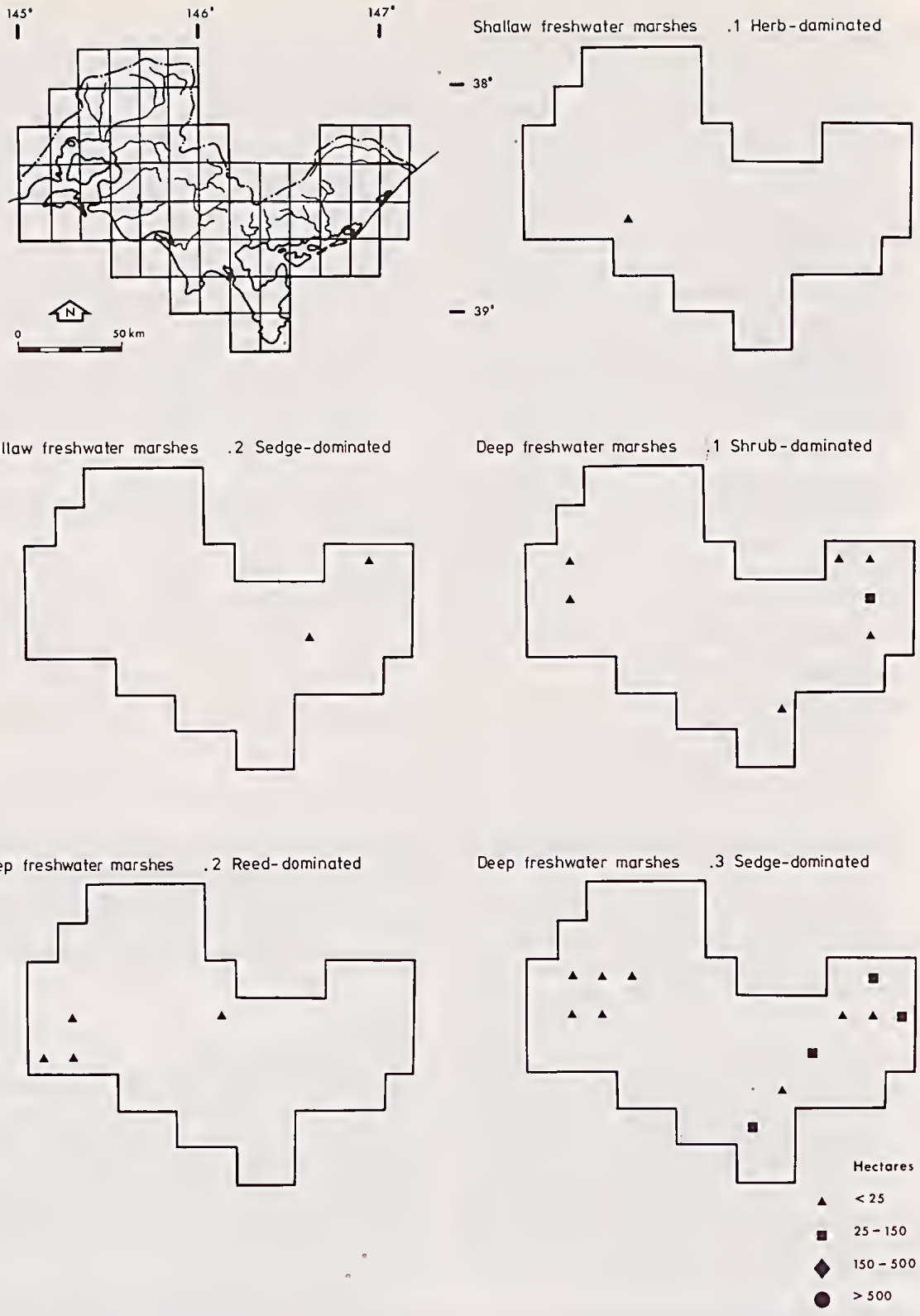

FIG. 2—The distribution (plotted on a 10′ grid) of the area (ha) of each wetland category and subcategory of the study area.

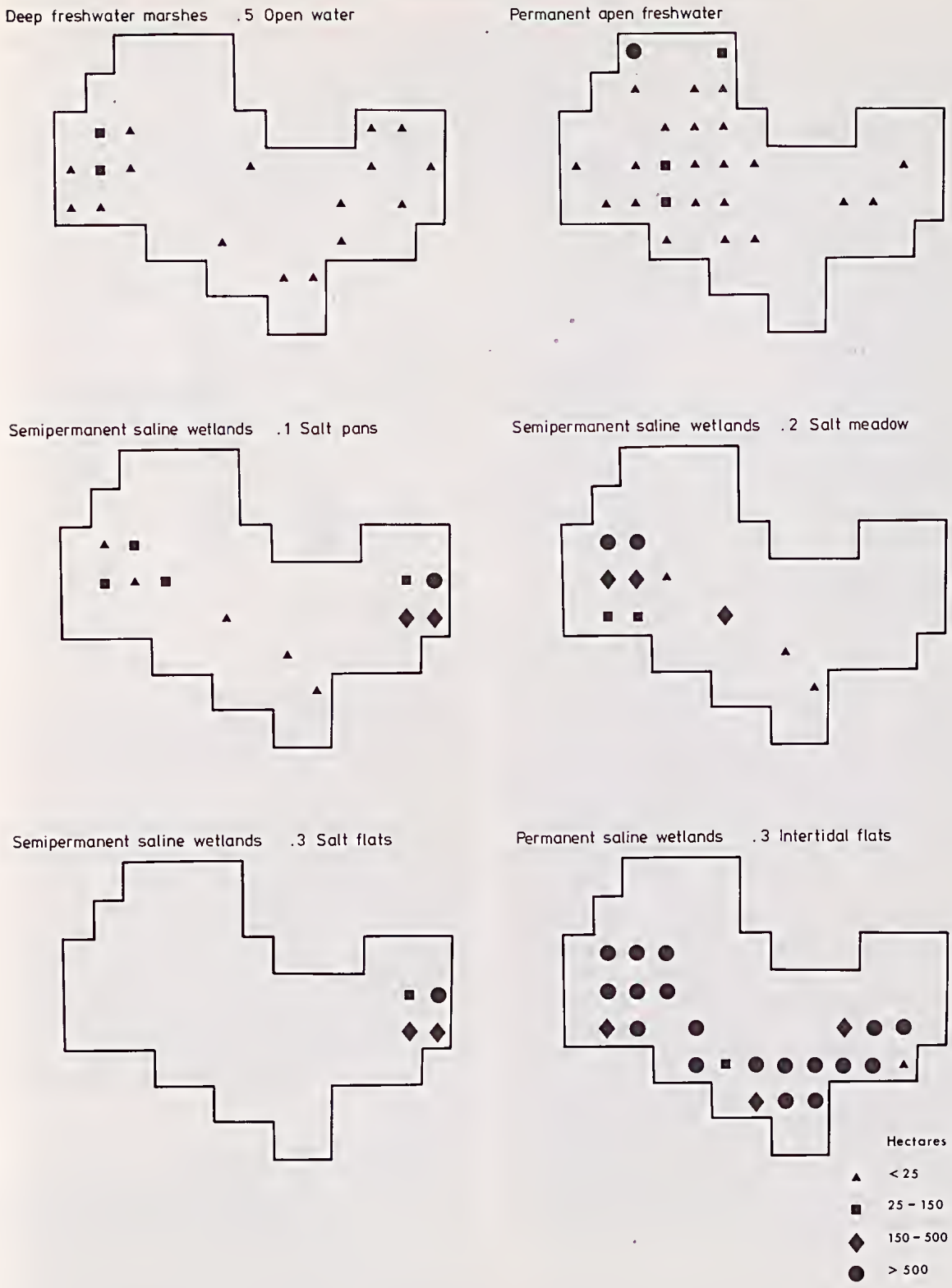

FIG. 2— (*continued*)

Table 3
Area of Wetland Categories and Subcategories in Each Wetland Size Range (Category 1 River flats have been omitted).

Category/subcategory	Area (ha) in wetlands of the following size ranges					Total area (ha)	
	1-5	6-10	11-25	26-100	>100	Subcategory	Category
3 Shallow freshwater marsh							9
.1 Herb-dominated	3					3	
.2 Sedge-dominated	6					6	
4 Deep freshwater marsh							555
.1 Shrub-dominated	2	1	31	35		69	
.2 Reed-dominated	1		24			25	
.3 Sedge-dominated	53	33		156		242	
.5 Open water	75	23	88	33		219	
5 Permanent open water	87	43		87	1500		1720
6 Semipermanent saline							4960
.1 Salt pan	32	7	41	98	1030	1210	
.2 Salt meadow	11	65	162	516	1930	2680	
.3 Salt flat				16	1050	1070	
7 Permanent saline							68700
.3 Intertidal mudflat					68700	68700	
Total area	270	172	346	941	74200		75900

tion of the wetlands across the study area is shown in Figure 2.

Drained wetlands, located during this study, show that since European settlement only small areas of saltwater wetland have been lost (total 200 ha) because of harbour works, land reclamation and seawall and floodgate installation, and that the area of freshwater wetland has been drastically reduced. Some 39 000 ha have been eliminated mostly by the drainage of extensive swamps north of Western Port (Koo-Wee-Rup Swamp 22 200; Cardinia Swamp 14 700 and Yallock Swamp 2000 ha) and near Anderson Inlet (232 ha). A further unknown area has been destroyed or greatly modified by minor drain construction and cultivation along the Powlett (2200 ha) and Tarwin (1700 ha) river flats which are still flooded regularly. The habitats drained were most probably deep freshwater marshes (e.g. East 1935) although the extent of appropriate subcategories is impossible to determine. Of the natural freshwater wetland which once occurred in the study area 95% has been destroyed.

Waterbird Distribution and Abundance

Waterbirds recorded, wetland categories they utilize, and breeding and numerical notes are provided in Appendix 1 and Table 4. The distribution of migratory waders recorded during the study is shown in Table 4. Seventy-three species of waterbird were recorded and 18 more have been recorded by other authors. The appendix shows that where large wetlands are absent a few species of waterbird (e.g. White-faced Heron, Black Duck, Masked Lapwing, ibis and Little Pied Cormorant) occur regularly, in small numbers, about farm dams along watercourses and on pasture. Concentrations of waterbirds mainly form on three habitats: deep freshwater marshes of French and Phillip Islands, where ibis, spoonbill and cormorant breed; salt pans and salt flats in the east that attract large numbers of waterfowl and waders; and extensive intertidal flats used by herons, ibis, gulls, terns, waterfowl and migratory waders.

Waterfowl Banding Data

There are no clear differences in the distribution of recoveries of banded ducks during open seasons (Figure 3), although Grey Teal returns have come from a wider area (38 ten-minute grid squares) than Black Duck and Chestnut Teal (both 27 squares). Distribution of band recoveries appears to reflect practicability of hunting rather than distribution of wetland: most returns come from large semipermanent saline wetlands and from

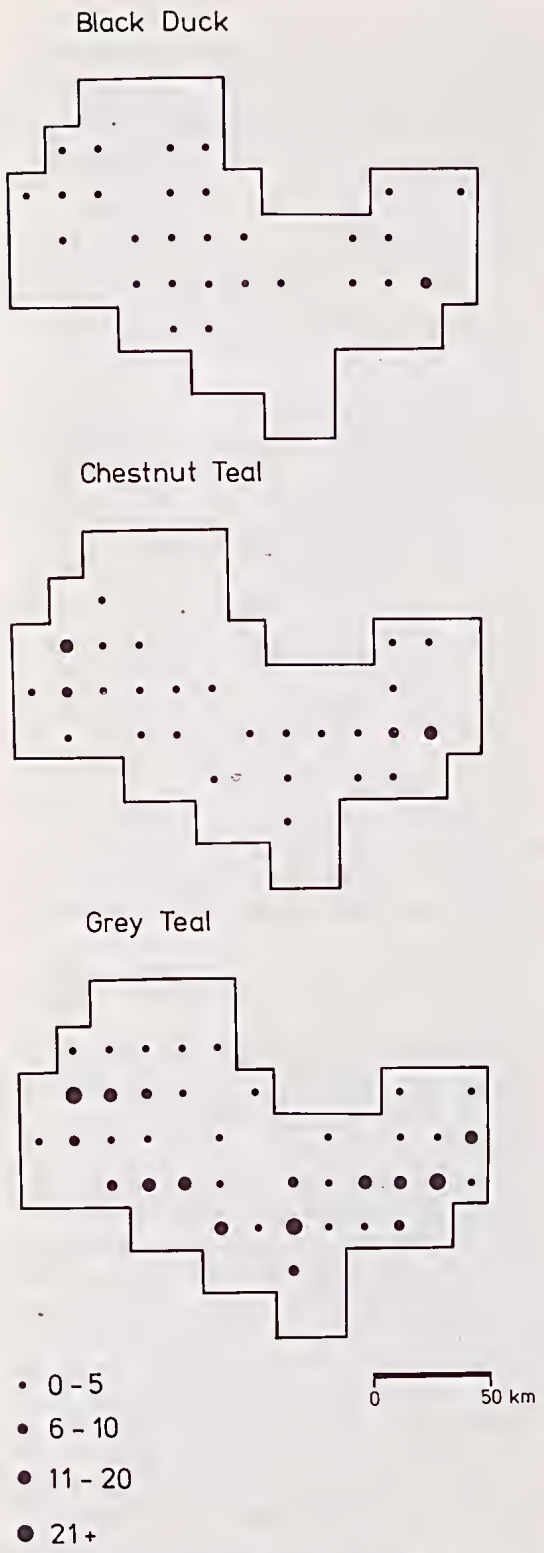

FIG. 3—The distribution (plotted on a 10′ grid) of recoveries of banded Black Duck and Grey and Chestnut Teal shot during open seasons between 1953 and 1977.

small freshwater swamps close to intertidal areas rather than intertidal flats where lack of cover, tides and difficulty of movement make hunting impracticable. Recoveries from many inland squares, particularly in the South Gippsland Ranges, indicate that some birds are shot at small farm dams and along watercourses, both habitats too small to be included in this study.

The study area appears to be more important for Chestnut Teal than for other waterfowl which have been banded, because it accounts for 14% of all Victorian recoveries of Chestnut Teal but only 4% of Black Duck and Grey Teal recoveries.

DISCUSSION

Destruction of extensive deep freshwater marshes, and of the water regime and vegetation along river flats has lowered populations of many waterbird species in the study area. Only a few species (e.g. Sacred Ibis, White-faced Heron) could have benefited from the pasture and agricultural land created by swamp drainage although some others (e.g. Black Duck, Little Pied Cormorant and Masked Lapwing) have become more widespread because of the numerous small farm dams created in previously forested area. Man-made wetlands do not compensate for the wetlands destroyed because they are not as extensive and they do not provide the same diverse habitats.

The area of wetland (75 900 ha) is similar to that about Gippsland Lakes (72 200 ha, Corrick & Norman 1980). However, there is much less deep freshwater marsh (1710 ha compared with 13 700 ha) and no large fresh or salt water lakes. Intertidal flats, absent about the Gippsland Lakes, are extensive.

The reduction in wetland area (35% of the total and up to 95% of freshwater wetland) has been more severe than about the Gippsland Lakes where 36% of the total and 34% of deep freshwater wetlands have been lost (Corrick & Norman 1980). The overall losses are also greater than found by comparable wetland surveys elsewhere in Australia (e.g. Goodrick 1970, Riggert 1966) where losses of 30-40% of the total and up to 60% of some categories have been recorded.

Where the only suitable habitats are small farm dams, streams, temporary pools or dry pasture, only small numbers of a few species of waterbirds occur regularly although small concentrations may form and remain on particularly suitable sites for some time. Most of the waterbird population is supported by wetlands of three categories (intertidal flats, semipermanent saline wetlands and deep freshwater marshes). Species (e.g. Hoary-

TABLE 4

THE MAXIMUM NUMBERS OF MIGRATORY WADERS, RECORDED DURING THE SURVEY, ON THE LARGER AREAS OF SUITABLE HABITAT.

Vagrant species and Double-banded Plover (a winter migrant) are omitted. Where counts of Loyn (1978) differ markedly they are shown in brackets. The areas are (from west to east): 1 northern, 2 eastern, 3 southern Western Port; 4 Anderson Inlet; 5 Shallow Inlet; 6 southern and 7 northern Corner Inlet; 8 western and 9 eastern Shoal Inlet and 10 Jack Smith Lake.

	1	2	3	4	5	6	7	8	9	10
Grey Plover		2				50	60	520	320	
Lesser Golden Plover	5 (23)	30	40	8	20	4	3	10	170	26
Mongolian Plover	(1)	(3)	32	1					80	
Large Sand Plover		2							26	
Ruddy Turnstone	4	4	80				4		120	50
Eastern Curlew	300	600	450	500	550	460	600	1100	600	
Whimbrel		1	2 (20)			20	1	100	60	
Grey-tailed Tattler	20 (80)	12	29				60	30	70	
Greenshank	100	200	1	250	6	70	300	60	400	2
Terek Sandpiper	2	4		3				1	2	
Bar-tailed Godwit	34 (11)	34	225	20	4	800	1500	1200	3200	5
Red Knot	(30)	50 (200)				300	120	50	900	40
Great Knot							10		170	
Sharp-tailed Sandpiper	(500)	200 (1000)	10 (254)	400				25	400	120
Red-necked Stint	1500 (2000)	2500 (5000)	1300 (3000)	2000	500	150	6200	1200	4000	3700
Curlew Sandpiper	1500 (3000)	2500	1400 (2000)	600	30	1600	5000	50	1500	80
Sanderling								4	60	

headed Grebe, Black Duck, Grey Teal, Musk Duck, Moorhen, Swamphen and Coot), which are numerous on freshwater wetlands to the east (Corrick & Norman 1980) are consequently far less numerous in the study area because of the lack of freshwater wetlands. The remaining deep freshwater marshes thus provide important habitat for these species in the study area, particularly during summer and autumn when most other freshwater habitats are dry. Also, several of the deep freshwater marshes on French and Phillip Islands are the only places where colonially nesting species (Straw-necked and Sacred Ibis, Royal Spoonbill and Little Pied Cormorant) breed in the study area. The large semipermanent saline wetlands (Jack Smith Lake and Lake Denison) are important breeding sites for waterfowl if they contain water during winter and spring and they are also important feeding areas for large flocks of swan, duck (particularly Grey Teal) and migratory waders during summer, but their value as drought refuge is low because they are usually dry during summer and autumn in years of below average rainfall when drought refuge habitat is most needed.

The most extensive wetlands and the most important for waterbirds in the study area are the intertidal flats which are feeding areas for herons, egrets, migratory waders, waterfowl, cormorants, gulls and terns. The number of birds using intertidal habitats is lowest during winter and spring when birds move to breeding areas or can use alternate feeding areas which become available in neighbouring pasture. During late spring and summer numbers then increase as temporary wetlands dry and migratory species return from breeding areas. Intertidal areas also provide drought refuge habitat for some species (e.g. Great Cormorant, Grey Teal and White Egret), irregular influxes of which occur particularly during summer, when the resulting flocks may remain from a few days to several months.

Migratory waders are easiest to count because they feed almost exclusively on intertidal flats and use traditional high tide roosting sites. When counts conducted during this study (Table 4) and by the BOC about Western Port (Loyn 1978) are compared with the few published observations elsewhere in Victoria they show that the study area supports the major part of the Victorian and probably south-eastern Australian (Thomas 1970) populations of several species.

Loyn (1978) indicated that in Western Port 6 species: Eastern Curlew, Whimbrel, Bar-tailed Godwit, Grey-tailed Tattler, Greenshank and Terek Sandpiper, '. . . were commoner than known normally elsewhere in Victoria'. However, each of these species (excluding Terek Sandpiper) is more abundant in Shoal and Corner Inlets than in Western Port. The number of Bar-tailed Godwit, in particular, is far higher than previously recorded elsewhere in Victoria (Loyn 1975, Smith 1966) or south eastern Tasmania (Thomas 1970). To these six species can be added Grey Plover which are more numerous in Shoal Inlet than on Mud Island and in Swan Bay which were the only places they were previously known to occur regularly (Wheeler 1960, Smith 1966, Klapste 1975). The study area also supports a large part of the known Victorian populations of Great Knot, Mongolian Plover and Sanderling, and the less abundant Large Sand Plover and Terek Sandpiper, which are all restricted to only a few sites elsewhere in Victoria (e.g. Smith 1966, Quinn 1967, Wheeler 1967, Cooper 1970, 1975, Klapste 1975, Loyn 1975, Carter 1976, Carter *et al.* 1976).

Intertidal flats and associated roosting sites in Shoal Inlet, northern Corner Inlet and Western Port are particularly important. The greatest threats to the extensive feeding areas would be large scale land reclamation, or widespread pollution. However, the number of places suitable for high tide roosting sites is limited and some roosts about Western Port are already disturbed frequently by fishermen and holiday makers. It is important that other roosts do not become exposed to similar disturbance because of improved access or development along the shore. Also some species, particularly Grey Plover, Whimbrel, Great Knot and Sanderling have habitat requirements restricting them to small areas of intertidal flats. This could make them vulnerable to minor changes in these preferred areas.

Wildlife Reserves and National Parks in the study area contain (a) a large proportion of the semipermanent saline wetland, and particularly salt pan, (Jack Smith Lake State Game Reserve), (b) the swamps with breeding colonies on French and Phillip Island (French Island State Park and Rhyll Swamp) and (c) small areas of sedge dominated deep freshwater marshes and salt flats (Wilsons Promontory National Park). If the Land Conservation Council recommendations (Land Conservation Council 1977) are accepted many of the wader roosts and wader feeding areas in Western Port will become Wildlife Reserves or Wildlife Co-operative areas. Unfortunately feeding and roosting areas for waders in Shoal Inlet and northern Corner Inlet, which are important to several species (Great Knot, Grey Plover, Mongolian Plover and Whimbrel) which are not common in Western Port, remain unreserved although they are adjacent to Nooramunga Wildlife Reserve.

Wetlands of the study area support many waterbird species which are distributed either in small numbers over the many small wetlands or occur in much larger numbers on the few wetlands which contain breeding colonies, the few extensive semipermanent saline wetlands and on intertidal flats. Requirements of the species using these three important wetland categories, particularly the need for undisturbed breeding and roosting sites, must be met if the waterbird populations are to be maintained along with representative areas of the variety of wetland types which are present.

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REFERENCES

Bibra, E. E. & Riggs, H. C. W., 1971. *Victoria River Gaugings to 1969.* State Rivers and Water Supply Commission, Melbourne.

Bowden, N., 1971. *Victorian Year Book 1977.* Number 91. Aust. Bureau of Statistics, Melbourne.

Brunt, B., 1961. Cape Barren Geese at Wonthaggi, Victoria. *Aust. Bird Watcher* 1: 180.

Bureau of Meteorology, 1968. *Review of Australia's Water Resources. Monthly rainfall and evaporation.* Bureau of Meteorology, Melbourne.

Carter, M. J., Bowker, G. & Isles, A. C., 1976. Large flock of Sanderling Port Fairy, Victoria. *Aust. Bird Watcher* 6: 173-177.

CCV, 1974. *Westernport region conservation survey.* Conservation Council of Victoria, Melbourne.

Central Planning Authority, 1968. *Resources Survey: West Gippsland Region.* Central Planning

Authority and West Gippsland Regional Committee, Melbourne.

Cooper, R. P., 1970. The Sanderling on Wilson's Promontory. *Aust. Bird Watcher* 3: 247-251.

———— 1975. *Wilson's Promontory National Park and its avifauna.* Bird Observers Club, Melbourne.

Corrick, A. H. & Norman, F. 1., 1980. Wetlands of Victoria 1. Wetlands and waterbirds of the Snowy River and Gippsland Lakes catchment. *Proc. R. Soc. Vict.* 91: 1-15.

Cowan, J. M., 1973. *The conservation of Australian waterfowl.* A.F.A.C. Special publication No. 2. Australian Government Publishing Service Canberra.

Davis, W. A., 1965. Field notes from south Gippsland. *Aust. Bird Watcher* 2: 134-138.

———— & Reid, A. J., 1974. Victorian Ornithological Research Group Report No. 1. The birds of the Sandy Point, Hastings districts, Westernport Bay, Victoria, Australia. Part 1. *Victorian Nat.* 91: 212-222. Part 2 *Victorian Nat.* 91: 264-269.

———— & ————, 1975. Victorian Ornithological Research Group Report No. 1. The birds of the Sandy Point, Hastings districts, Westernport Bay, Victoria Australia. Part 3 *Victorian Nat.* 92: 60-70. Part 5. *Victorian Nat.* 92: 163-171. Part 6 *Victorian Nat.* 92: 194-196.

Department of National Development, 1966. *Atlas of Australian Resources.* Department of National Development, Canberra.

East, L. R., 1935. Swamp reclamation in Victoria. *J. Inst. Engineers Aust.* 7: 77-79.

Frith, H. J., 1967. *Waterfowl in Australia.* Angus and Robertson, Sydney.

Goodrick, G. N., 1970. A survey of the wetlands of coastal New South Wales. *CSIRO Div. Wildl. Res. Tech. Mem.* 5.

Hills, E. S., 1964. *The physiography of Victoria.* Whitcomb and Tombs, Melbourne. 4th ed.

Hyett, J. & Gottsch, M. D., 1966. The birds of Quail Island, Victoria. *Aust. Bird Watcher* 2: 51-55.

Jenkins, J. J. 1968. The geomorphology and upper Cainozoic geology of south-east Gippsland, Victoria. *Mem. geol. Surv. Vict.* 27.

Johnstone, K. A. & Johnstone, G. W., 1974. Palaearatic waders overwintering at Sunday Island. *Aust. Bird Watcher* 5: 188-190.

Joseph, R., 1975. The Tarago-Westernport Pipeline. *Aqua* (Winter): 2-3.

Klapste, J., 1975. Some notes from Mud Island. *Aust. Bird Watcher* 6: 79-82.

Land Conservation Council, Victoria, 1977. *Final recommendations Melbourne study area.* Land Conservation Council, Melbourne.

Loyn, R. H., 1975. *Report on the avifauna of Westernport Bay.* Ministry for Conservation, Victoria.

————, 1978. A survey of birds in Westernport Bay, Victoria 1973-74. *Emu* 78: 11-19.

Loyn, R. H. & Bingham, P., 1976. Westernport survey. *Bird Observer* 543: 34-35.

————, 1978. Westernport Survey. *Bird Observer* 556: 120-121.

McNally, J. & Falconer, D., 1953. Trapping and banding operations, Lara Lake, 1952. *Emu* 33: 51-70.

Norman, F. 1., 1973. Movement and mortality patterns of black ducks and mountain ducks banded in Victoria. *Proc. R. Soc. Vict.* 86: 1-14.

Quinn, D., 1966. Tarra Valley and Bulga Park. *Bird Observer* 411: 8.

Quinn, D. J., 1967. The large Sand Dotterel on French Island. *Aust. Bird Watcher* 3: 44-46.

Raou, 1978. Recommended English names of Australian birds. *Emu* 77: 245-313.

Riggert, T. L., 1966. *Wetlands of Western Australia, 1964-1966.* Department of Fisheries and Fauna, Western Australia, Perth.

Simpson, Y., 1977. Unusual Sighting Report. *Bird Observer* 547: 47.

Smith, F. T., 1966. Wader observations in southern Victoria, Part 1. *Aust. Bird Watcher* 2: 70-84.

————, 1967. Wader observations in southern Victoria, Part 2. *Aust. Bird Watcher* 3: 19-29.

Thomas, D. G., 1970. Fluctuation of numbers of waders in south-eastern Tasmania. *Emu* 70: 79-85.

Wheeler, R., 1960. The Grey Plover on Mud Island, Victoria. *Aust. Bird Watcher* 1: 107-109.

————, 1962. Further notes on the Grey Plover. *Aust. Bird Watcher* 1: 204.

Wheeler, W. R., 1967. *A handlist of the birds of Victoria.* Victorian Ornithological Research Group, Melbourne.

APPENDIX 1.

List of Waterbirds Recorded in the Study Area with Notes on Their Distribution and Abundance. The 17 species of migratory waders listed in Table 4 are excluded. [Common names are from RAOU (1978)].

Great Crested Grebe Small groups occur irregularly, mainly about Corner and Shoal Inlets, also a permanent resident on some reservoirs (Davis & Reid 1974). Maximum seen 54 on Corner Inlet in October 1977.

Hoary-headed Grebe Usually in pairs but larger groups (up to 50) on inlets during autumn.

Australasian Grebe Freshwater only, the few records made reflect lack of suitable habitat.

Australian Pelican Variable numbers in tidal inlets, larger farm dams and water storages. About 120 regularly roost in salt marshes on the northern shore of French Island where they have bred (Loyn 1975, 1978).

Black-faced Shag Off-shore waters, single birds or small groups near the entrances to inlets except Corner Inlet where up to 300 roost on navigation beacons and Granite Island.

Great Cormorant Usually single or a few birds on dams and rivers; but large concentrations occasionally for short periods on inlets (e.g. 4000 in Corner Inlet March 1977); has bred at Coolart Lagoon, 5 km south of Crib Point (Davis & Reid 1974).

Pied Cormorant The least abundant cormorant, restricted to tidal inlets where groups form at high-tide roosts, groups of up to 140 in Western Port and to 30 in Corner Inlet. It has bred in the study area (Loyn 1975).

Little Black Cormorant Individuals and small parties throughout.

Little Pied Cormorant Widely distributed and abundant, breeds at Rhyll Swamp, Phillip Island; Coolart Lagoon, and on French Island.

Pacific Heron Pairs or single birds around dams and on pasture, unusual on intertidal flats.

White-faced Heron Abundant on all wetlands and pasture, numbers increase on tidal flats in late summer.

Cattle Egret Winter visitor to pasture, often roosts in trees over water. A flock of 170 near Wonthaggi, June 1977.

Great Egret Singly or in parties throughout, numbers vary, particularly about mudflats e.g. 35 at the mouth of Bunyip River December 1976.

Little Egret Up to 9 near Port Albert but generally singly about inlets in the east. Few previous records in south east Victoria (Wheeler 1967).

Rufous Night Heron Lower reaches of most rivers, Warneet and at Koo-Wee-Rup; Breeds near Hastings (Davis & Reid 1974).

Sacred Ibis, Straw-necked Ibis Abundant on pastures throughout, the latter are rarely seen on intertidal flats. Both breed at Clump Lagoon (1000 nest October 1977), Heifer Swamp (280) and Little Heifer Swamp (300) on French Island. Moving to mudflats and mainland pasture to feed. Up to 400 pairs of Sacred Ibis nest at Coolart (Davis & Reid 1974) and both nest in Rhyll Swamp, Phillip Island. The breeding swamps and trees in other swamps and farm dams are used as roosting places at night.

Royal Spoonbill Breeds at Rhyll Swamp, Coolart Lagoon (Davis & Reid 1974) and at swamps on French Island. Flocks of up to 40 occur on all intertidal flats and move to neighbouring pasture during floods.

Yellow-billed Spoonbill Singly or in small groups on small swamps and farm dams throughout, rarely on mudflats.

Black Swan On large farm dams and swamps throughout, often moving onto adjacent pasture to feed. Very large concentrations on intertidal flats of all inlets in summer e.g. Shallow Inlet 1500 January 1977, Corner Inlet 8000 March 1977, and Shoal Inlet 5500 November 1977. Many in these concentrations become flightless during moult.

Cape Barren Goose Small flocks on pasture at traditional sites (e.g. near Shallow Inlet) during summer. Occasionally appears elsewhere (Davis & Reid 1975, Brunt 1961). Roosts on small islands in Shallow Inlet (Cooper 1975).

Australian Shelduck Mainly on salt flats, salt pans and intertidal flats, and occasionally on pasture near farm dams.

Pacific Black Duck Pairs and small parties on dams and swamps with some cover, large concentrations on large open wetlands (e.g. 600 Jack Smith Lake January 1977). Rarely on intertidal flats.

Grey Teal Pairs and small parties throughout and large concentrations on intertidal flats and Jack Smith Lake.

Chestnut Teal Pairs and small parties on large farm dams, and flocks to 300 on intertidal flats, particularly during summer and autumn.

Australasian Shoveler Only small numbers recorded during the study. A pair with young on a farm dam on French Island, and many birds paired evidently in preparation for breeding at Jack Smith Lake in August 1978.

Pink-eared Duck Only at Jack Smith Lake (2 in July 1977 and 380 in August 1978).

Hardhead Mainly on open freshwater wetlands, occasionally on other habitats.

Maned Duck Most common around farm dams in the east, small numbers near Foster and Wonthaggi.

Musk Duck Usually pairs or individuals on freshwater swamps and large farm dams, flocks do form (e.g. Drouin sewerage farm, 100 in July 1977; 80 in northern Western Port, May 1978; 260 in Western Port in June 1977 (Loyn & Bingham 1978).

White-bellied Sea Eagle Western Port (1 pair), McLoughlan Beach (1 pair) and Corner Inlet (1 pair). Three birds, including 1 juvenile, in Anderson Inlet in May 1977. Also around Wilsons Promontory (Cooper 1975).

Marsh Harrier Pairs throughout the study area but most numerous on French Island.

Buff-banded Rail One in a roadside ditch near Anderson Inlet January 1977. See also (CCV 1974),

Wheeler (1967) and Davis & Reid (1975) for alternate assessments of status.

Purple Swamphen, Dusky Moorhen A few scattered along the lower reaches of rivers, on large dams with scrub or reed cover and on freshwater wetlands. Rare on saline wetlands.

Eurasian Coot Mainly large farm dams (flocks to 50) and reservoirs (flocks to 150) and Jack Smith Lake when full. Hardly ever on tidal inlets.

Pied Oystercatcher Intertidal flats, breeding behind ocean beaches and on small islands; flocks to 80.

Sooty Oystercatcher Less widespread than Pied Oystercatcher but flocks form, particularly during summer and autumn, in southern Corner Inlet and Shoal Inlet (to 120).

Masked Lapwing All wetlands and agricultural land, abundant.

Hooded Plover Mainly on ocean beaches, where it breeds, and occasionally in inlets and on saltpans close to the sea, small numbers only.

Double-banded Plover April to August in flocks of up to 200 on tidal flats and occasionally on short pasture and fallow away from water. Up to 1500 have been recorded in Western Port (Loyn 1978).

Red-capped Plover Common on intertidal mud and sand flats and semipermanent saline wetlands.

Black-fronted Plover Occurs occasionally around large farm dams and freshwater swamps. Davis & Reid (1975) recorded it breeding.

Black-winged Stilt Jack Smith Lake (January 1977) and salt marshes at Bunyip River mouth (October 1976); an infrequent visitor probably because of the lack of shallow freshwater swamps.

Red-necked Avocet One Jack Smith Lake (July 1977); normal range is to the north and west of Melbourne.

Common Sandpiper Less than 30 individuals in the study area, found separate from the other migratory waders, singly or in twos or threes, along the tidal reaches of creeks and rivers e.g. Tarwin and Tarra Rivers and about Western Port (Loyn 1975).

Latham's Snipe Rarely recorded in swampy drains and ditches close to the coast near Port Albert and Anderson Inlet, on salt flats on French Island and near the mouth of the Bunyip River. May also occur in small swampy areas of pasture—a habitat not included in the present study.

Black-tailed Godwit Single bird Corner Inlet March 1978, (see also CCV 1974, Simpson 1974, Loyn & Bingham 1978).

Silver Gull Very abundant, in coastal areas, but occurs throughout particularly on rubbish tips and cultivated land. Nests on several islands in Shoal and Corner Inlets.

Pacific Gull Along the coast but numbers change seasonally as birds move to offshore islands to breed.

Gull-billed Tern Intertidal flats and channels at river mouths in Shoal (up to 30), Anderson (up to 8) and Corner Inlets (up to 30) and occasionally in Western Port (up to 9) (CCV 1974, Davis 1965, Loyn & Bingham 1978).

Caspian Tern Small numbers along the coast and throughout inlets e.g. Shoal and Corner Inlets (100), Anderson Inlet (10) and Western Port (60) Loyn & Bingham 1978). Nests on Ram Island (off southern French Island) and on islands in Shoal Inlet. Breeding birds easily disturbed by people and grazing stock.

Common Tern Summer visitor mainly to Shoal Inlet (140 Jan. 1977). Rare in inlets and along the coast west of Wilsons Promontory.

Little and Fairy Tern Large flocks (to 170) in eclipse plumage (when they are inseparable) about Corner and Shoal Inlets between October and April. Adult Little Terns only recorded east of Corner Inlet. Fairy Terns nested on islands in Shoal Inlet and Western Port.

Crested Tern Common along the coast and in inlets. Flocks to 300 form on broad beaches and spits particularly when birds return from feeding off the coast. Several pairs nested on an island in Shoal Inlet.

Other species, that are irregular visitors, that have been recorded in the study area but not seen during this survey period are: Darter (Davis & Reid 1974, Wheeler 1967, Hyett & Gottsch 1966); Brown Bittern (Davis & Reid 1974, Cooper 1975, CCV 1974); Brolga (Wheeler 1967) Freckled Duck (Wheeler 1967); Blue-billed Duck—Woodside Beach September 1978 (Loyn 1978, Loyn & Bingham 1978); Lewin's Rail, Baillon's Crake, Australian Crake, Spotless Crake (Wheeler 1967, Davis & Reid 1974, 1975, CCV 1974, Cooper 1975); Painted Snipe (Wheeler 1967, CCV 1974, Davis & Reid 1975); Banded Lapwing (Loyn 1975, Davis & Reid 1975, Wheeler 1967); Red-Kneed Dotterel (CCV 1974, Loyn & Bingham 1976, Loyn 1978); Little Curlew (Cooper 1975, CCV 1974); Wood Sandpiper (Loyn 1978); Pectoral Sandpiper (CCV 1974); Oriental Pratincole (Loyn 1978); Whiskered Tern (Loyn 1978, Wheeler 1967, CCV 1974); White-winged Tern (Quinn 1966).